Observations on
Conopholis Americana

—

Wilson

Observations on Conopholis

Observations on Conopholis Americana.

(*WITH PLATES I-VI.*)

By Lucy L. W. Wilson, Ph. D.

Head of the Biological Department, Philadelphia Normal School.

[Thesis presented to the University of Pennsylvania]

I. History and Literature.

IT is now nearly twenty-two hundred years since Theophrastus Eresius (died 286 B. C.) appropriately bestowed upon a plant, which still bears the same name, the title of *Orobanche*, literally peachoker. This name in extended form was afterwards applied to the whole order, which now includes some hundred and fifty species. Yet, in spite of the lapse in time, the family itself has been comparatively little studied. This seems doubly strange when one recalls their peculiar habits of growth, habits so well known and so characteristic that it was in describing them that Micheli in 1720 ("*De Orobanche*") first used the now common word parasite.

The literature cited in Engler-Prantl's "Pflanzenfamilien" by Günther Beck von Mannagetta in 1891 is given below.*

To this should be added Chatin's "Anatomie Comparée des Végétaux. Plantes Parasites," (Paris, 1892).

The absence of literature is especially noticeable in the case of the species which is the subject of this paper. With the exception of the mention of its gross specific characters in the various Floras and Prodromuses, most of which have been cited above, from the time of Linneus to the present, nothing

* Wallroth, Orobanches Generis (1825); Vaucher, Monographie des Orobanches (1827); G. Beck, Monographie der Gattung *Orobanche* (1890), Bibl. Bot. Heft 19; Baillon, Hist. des Plantes (1891); Endlicher, Gen. Plant (1836–1840); Reuter in D. C. Prod. XI (1847); Hooker and Bentham's Gen. Plant. II (1873); Hooker, Flora Brit. Ind. (1885); Gray, Syn. Flora N. Am., II (1886); L. Koch, Die Entwicklungsgeschichte der Orobanchen (Heidelberg, 1887); Hovelacque, Rech. sur l'appareil veget. des Bign. Rhin. Orob. (Paris, 1888).

had been added to our knowledge of the plant, except what was implied in Wallroth's separation of it from the genus *Orobanche*, where it had been placed by Linneus, and its erection into a separate genus *Conopholis*, in 1825. Of this genus it was the solitary species until Sereno Watson described a second, *Conopholis mexicana.*

In 1892, it is true, Dr. Chatin published his work on Parasites, in which three pages of text and one of illustrations lithographed from free-hand drawings, are devoted to the histology of *C. americana.* The material with which he worked, however, must have been quite scanty and young, for a careful study of the fine anatomy of the plant shows that in most instances his statements and drawings do not conform to conditions in the adult plant. The details of the many points of difference will be given later on. Material for the present study was collected by Professor Macfarlane in the Allegheny Mountains, near Gallitzen, during June of 1896, and my investigations have been made under his direction.

II. Geographical Distribution.

Conopholis americana, as its specific name indicates, is a distinctly American plant. It is not very commonly found, but has rather a wide distribution. Gray says in the last edition of the "Manual," "New England and Michigan, south to Florida and Tennessee, May and June."

The following more exact information is due to the kindness of several botanists to whom I desire here to make acknowledgment.

New York.—Staten Island, Garretson's. A. A. Tyler (Herbarium of Lafayette College, Dr. Thomas C. Porter).

New Jersey.—Sussex County, near Newton. A. P. Garber (Herbarium of Lafayette College, Dr. Thomas C. Portei).

Pennsylvania.—Chester County, R. Kipington. Lancaster County, Mouth of Tuequanhe, N. A. Heller. Franklin County, Mercersburgh. Allegheny County, Wall's R. R., S. W. Knipe. Mercer County, Middlesex, A. P. Garber.

All of the above information was gained from the Herbarium of Lafayette College and given me by Dr. Thomas C. Porter. It is also reported from Delaware County (Dr. George Smith's Catalogue), but no locality is given. Bucks County (J. S. Mayer's Catalogue). Chester County, rich woods along the Brandywine (Darlington's *Flora Cestrica*).

Virginia.—Blue Ridge Mountain, Turhe's Gap, Albemarle County, J. D. Tinsley. Smyth County, J. K. Small (Herbarium of Lafayette College, Dr. Thomas C. Porter).

West Virginia.—Cheat Mountains, L. C. Corbett. Decker Creek, L. C. Corbett.

North Carolina.—Watauga County, Blowing Rock, Small and Heller (Herbarium of Lafayette College, Dr. Thomas C. Porter).

South Carolina.—Northern part, above lower limits of Piedmont plateau, W. W. Ashe.

Georgia.—Northern part, W. W. Ashe.

Florida.—Near Apalachicola. This region has now been built up, and the plant is in consequence no longer found there; A. W. Chapman. Chattahoochee, A. W. Chapman. Lake City, P. H. Rolfs. Ocala, J. D. Smith (Baltimore). Hibernia, W. M. Canby (Herbarium of Lafayette College, Dr. Thomas C. Porter).

Ohio.—One and a half miles east of Oberlin, Albert Norris.

Indiana.—Locality not given, Thomas MacBride.

III. Time of Flowering.

The flowering shoots, which are the only parts of the plant that appear above ground, have been found in the Pennsylvania woods in early May, just beginning to flower (May 10, 1890, Lancaster County, N. A. Heller) and continue in full bloom until certainly the third week in June (Gallitzen, Pa., Professor Macfarlane).

The following dates have been variously reported:

Chester County, June 27, past flowering.

Franklin County, May 23, in flower.

Allegheny County, June 19, in full flower.

Mercer County, June 12, in full flower.

It was reported from Staten Island, N. Y., as in fruit July 11, 1895; and coming southward into southwestern Virginia, it was there already past bloom as early as June 8, 1892; in flower, but passing out, in Blowing Rock, N. C. (exceptionally high), June 16–17, 1892; while in Florida, it was in flower as early as March and April.

Apparently, then, the period of flowering lasts about two months, beginning in early May in our Middle States, but, as might be expected, even two months earlier farther south.

IV. Relationship to Other Members of the Order.

The flowering stalks, always some distance from the trunk of the host, are remarkable in appearance. Unlike the other members of this order, they are thick and fleshy. Their color is a chestnut brown. They are six inches in length when fully grown, covered with thick, membranous-fleshy scales, in the axils of the upper ones of which are found the flowers. These are of the same color as the leaves, and like all of the *Orobancheæ*, have a marked resemblance to non-parasitic *Scrophulariaceæ.* There are two bracts at the base of the calyx, which is irregularly four to five-toothed and split posteriorly to the base. The upper lip of the two-parted corolla is entire, or notched; the lower three-parted with the middle division obtuse and larger than the other three. The stamens are protruded, and the one-celled ovary is full of ovules attached to four parietal placentæ. These differ but slightly from the flowers of the other closely related American genera, *Phelipæa* and *Aphyllon.* The most noticeable point of difference is the protruded stamens.

The calyx of *Phelipæa* is not cleft down the middle, and there is a well-developed ovarian gland, of which there is also a microscopic indication in the very young flowers of *Conopho-*

lis. It has also the two bracts. According to Chatin, there is a close correspondence in the peculiar histological characteristics of the two genera. He figures for both the same arrangement of bundles, and the same kinds and distribution of parenchyma.

This seems to indicate that these two genera certainly, and possibly *Aphyllon* also, might be better included as species of a single genus. Unfortunately, as I shall show later, no reliance can be placed on Chatin's work.

V. The Host Plant.

The host of *C. americana* is given by Gray as the oak. Dr. Thomas Porter gives the same observation, as do the following: P. H. Rolfs, L. C. Corbett and W. W. Ashe. Mr. Albert Norris reports to have seen it in two cases under maple trees, and Rolfs reports it under oaks and beeches. In all cases, where the parasite has been traced to its attachment, it has been invariably found to be parasitic on the oak. It is, however, frequently quite a distance from the trunk of its host, which may account for its being found under other trees. There is no positive evidence in favor of any other than an oak attachment.

VI. Duration of Life.

The flowering shoots are undoubtedly of annual development, probably from buds formed the previous year in tubercles whose length of life must depend upon the capacity of the host to feed the parasite.

It was impossible to determine accurately the age of the tubercle. The relationship between its size and the age of the oak root was the only clue that I could get of the age of the parasite. Tubercles half an inch in diameter, with small buds which had apparently just pierced the cortex, were found on roots three and four years old. The oak root, whose photograph is shown in Plates I and II, is fully eleven years

of age. The tubercle itself measured about six inches in diameter.

From these facts and others which are tabulated below, I concluded that the seed usually germinated on quite young roots; but that it did not send up a flowering shoot until perhaps its fourth or fifth year of existence.

The subjoined table shows the size of some tubercles, and the corresponding age of the oak root on which they were parasitic:

Age of Oak Root in years.	Diameter of tubercle.
3	1 inch.
5	2 inches.
5	3 inches.
5	3½ inches.
6	1¾ in. x 1 in.
6	2½ inches.
6	3½ inches.
7	2 inches.
7	2½ inches.
8	2½ inches.
8	3 inches.
9	4 inches.
10	4 inches.
11	6 inches.

VII. Relationship between Conopholis and its Host.

The flowering shoots of *C. americana* are found above ground usually some distance from the oak and often forming almost a semi-circle of growth around it. Sometimes above ground, too, are found the tubercles from which the stalks proceed. This was particularly true at Gallitzen, Pa., as observed by Professor Macfarlane. But it is only by digging below the ground that any idea can be had of the huge excrescences made by the parasite and the roots of the oak. Three of these are figured on Plate I, which is a photograph of a small portion of the underground material dug up at Gallitzen, Pa., June, 1896. Younger stages are drawn on Plate VI, Figs. 1, 2, 3 and 4.

It will be noticed that from all of these tubercles spring flower stalks in various stages of development. The larger tubercles, such as are figured in Plate I, are almost completely covered with such stalks. Curiously enough, however, there are few transition stages between the adult stalks and the very numerous young buds. The material was gathered near the close of the flowering period. Therefore, it may be that these buds remain dormant until the next year. It seems quite as probable however, that, like other parasites, they are capable of very rapid growth, and that transition stages are rarely found because the transformation takes place rapidly.

The buds are protected by the scale leaves, which, in the young state, are rather fleshy than membranous. The tubercle itself is covered with a thick, coarse, porous, dark-brown "bark," which scarcely holds together the innumerable granules of sclerenchyma which make up the great mass of the excrescence. Plates II and III, which are photographs of a tubercle and the host oak root cut through the middle, show quite clearly the enormous quantity of sclerenchyma in such a growth. Plate V, Fig. 5, is a drawing of a cross section through one of these patches. It will be noticed that it resembles markedly sclerenchyma groups, which are normally developed in the cortex of the oak, and are, indeed, characteristic of it.

These photographs do not show what was particularly striking in the material itself, namely, that wherever a flower stalk had been, there were left behind large masses of sclerenchyma embedded in dead cellular tissue.

Plates II and III alike show three large nodules, the centres of which are undoubtedly oak, much more compact and with fewer groups of sclerenchyma than the others. The lower nodule of Plate II indicates, perhaps, how the oak wood gradually became isolated from the surrounding wood, thus forming apparently comparatively unattached centres. The middle one of these three large nodules dropped from the rest, plainly

showing that it now had no organic connection with the rest of the oak, and this in spite of the fact that there can be no doubt that its centre was once a part of the oak root.

It will be seen (Plate III) that these patches of sclerenchyma are found in the cortex of the oak root, that they gradually become larger and more numerous until finally they make up the bulk of the excrescence, and also that the diameter of the root increases in proportion to the amount of sclerenchyma present.

Not only is the sclerenchyma continuous, but the "bark," it will be noticed, covers, without apparent interruption, the root of the oak and the tubercles.

The lines of invasion of the host by the parasite may be made out clearly in both of these plates, particularly if one looks carefully at the lower half. But in such natural specimens it would be difficult to understand the relationship of the parasite to the host, even with the most careful microscopic study. A study of the younger nodules, however, enables us to understand the larger growths.

The youngest tubercle which I was able to find in the keg of material brought from Gallitzen was about half an inch in diameter, and growing at the end of a root fully three years old. The tips were already developed, tiny scales covering the rudiment of a flower stalk (Plate VI, Fig. 1). Figs. 2 and 3 are drawings of tubercles of about the same size and apparent age. Fig. 2 has, however, more flower-stalk buds, which are farther developed in Fig. 3. In Fig. 2 is drawn a tubercle, beyond which the root still extends. The same thing will be noticed in Plate I. Nevertheless it was fairly unusual to find roots extending beyond even the younger tubercles. Like other parasites, it seems most frequently to prevent their growth and development, by cutting off and absorbing the nourishment originally intended for the younger parts of the root.

Like the older tubercles, these were masses of scleren-

chyma, covered with bark and held together by soft delicate tissue.

It was very difficult to get vertical sections of any of these tubercles, owing to the large quantity of sclerenchyma, the softness of the connecting tissue, coupled with the very different character of the oak root. Still the photomicrograph reproduced in Plate V, Fig. 5, gives a very fair idea of the state of affairs, although it is not quite through the middle of the tubercle, and does not, in consequence, show at its apex the scale leaves which cover over and form a part of the very young flower bud, which was noticed in Plate VI, Fig. 1.

The "bark" is very thick and clearly made up of several layers. Below it are patches of sclerenchyma that lie embedded in soft, rather long-celled tissue, which, both in the photograph and in reality, takes the form of anastomosing lines. Completely surrounding the patches of sclerenchyma, at the base of the flower stalk and in it, this becomes gradually transformed into vascular and parenchymatous tissue.

The apparent line of demarcation between this tissue and that of the oak host is plainly shown in the photograph. It extends longitudinally across, with downward invasions, into the solid oak below, which, in its turn, spreads out fan-wise above.

At first sight it would seem that this strongly marked line was the separation between parasite and host; that all above it was certainly *C. americana*, and all below was equally certainly *Quercus rubra*. There are, however, one or two objections to this:

The sclerenchyma patches strikingly resemble such as the oak normally develops, in a more limited quantity and at a later period, in the cortex tissue. At the same time the ramifying soft tissue is plainly and unmistakably that which afterward becomes differentiated into the fundamental and the vascular tissue of the parasite, so that above this line of apparent separation there is a possibility that both host and parasite

are present. Now, it is perfectly conceivable that the irritation to the oak caused by the continued downward growth of the parasite would have the effect of hastening the formation of the sclerenchyma, thus effectually resisting further attack of the parasite, which would then perforce penetrate more and more deeply into the oak with the same result of sclerenchyma formation following its progress.

In this connection, the drawings in Plate VI, Figs. 1 and 2, are most suggestive. The root of the oak actually rises up to meet the parasite. In the vertical section (Plate V, Fig. 5), its solid tissue spreads outward and upwards into the softer tissue above.

Plates I, II and III can now be understood. Each of the three tubercles in Plate I is the growth of a single seedling. The difference in size is the consequence of the varying age of the parasitic mass. These tubercles are partly the result of the growth of the host, due to irritation of its tissue. This growth of the host is shown in the swollen appearance of the root, just below as well as in the base of the tubercle, and also in the masses of sclerenchyma which make up the greater part of each tubercle. The parasite proper consists of the flowering stalks and buds, also of an undetermined part, perhaps the whole of the parenchymatous tissue, which ramifies through the tubercle in every direction, surrounding and holding together the sclerenchyma patches and, as is shown in Plates II and III, penetrating the as yet unchanged bast and wood of the oak root. To the host, on the contrary, besides its evident possessions, may be attributed the "bark," the sclerenchyma, and, possibly, a part of the ramifying parenchymatous tissue.

The only argument against this is the fact easily seen in Plate IV, Figs. 1, 2, 3 and 4, that the patches of sclerenchyma are found at the base of flower shoots, in what is undoubtedly the tissue of the parasite. On the contrary, however, they are never found, except at the very base of the adult shoot.

The tubercles are, in the main, a modification of the host, within which develop endogenously the buds of the flower shoots, which then break through the thick, protecting "bark."

This peculiar relationship of parasite and host recalls in its development and growth the *Balanophoreæ*, or even the *Rafflesiaceæ*, rather than the typical *Orobancheæ*, whose connection with the host plant in all genera and species which have been carefully worked out, is a much more evident and a much less intimate one. These always develop some earth roots in addition to the haustoria. This is never true of either of the above orders, in both of which the flower is the only part rising free from the host.

Langsdorffia and *Balanophora* are typical members of the order *Balanophoreæ*, whose history and parasitic relationship have been carefully worked out by Sachs and Eichler, more particularly the latter. The seed of each, in germinating, destroys the bark and cortex of the host roots, lays open, lacerates, and unravels the tissues in the search for food. Then the woody bundles of the host ascend into the substance of the parasite, spread out like a fan, and become so interlaced with the cells and vessels of the parasite that it is quite impossible to distinguish one from the other.

VIII. Histology of C. americana.

Under this head will be taken up mainly the microscopic anatomy of the flowering stalk. As much of the histology of the tubercle as I was able to make out has been already discussed. But to make what follows clearer, I will recapitulate the chief points mentioned. All are quite plainly demonstrated in Plate V, Fig. 5, namely, the thick "bark," continuous and identical with that of the oak, the masses of sclerenchyma, and the threads of soft parenchymatous tissue surrounding these masses.

Mature Flowering Shoots.

A cross section, through any part of the flowering shoot above the tubercle, shows the following structure:

(*a*) An epidermis made up of rather thick-walled cells, filled with a yellowish-brown protoplasm.

(*b*) Parenchyma, made up of cells of varying size and thickness. The intercellular spaces are large and frequent.

(*c*) Two concentric rows of separated collateral fibro-vascular bundles.

All of these points may be seen in Plate V, Figs. 1 and 3, and are not particularly noteworthy, although the double row of separate bundles is rather uncommon.

Figures 2 and 3 on Plate V show the very remarkable relation of these bundles. Each bundle of the inner row has internally xylem, made up of xylem cells and well-developed spiral tracheæ. Next to the xylem is found the phloem, which a longitudinal section proves to consist of both sieve tubes and companion cells. Adjacent to the phloem are a number of parenchyma cells, whose walls are so angular and so much thickened, that in the photograph, these bundles appear to be bi-collateral. That such is not the case, however, is easily proved on longitudinal section, when the parenchymatous nature of these cells is at once visible. Even in cross section, the color of the walls differentiates the wood from the thickened parenchyma.

The bundles of the exterior row have the same structure as those of the interior, only the xylem is now exterior so that the phloem masses of the two rows face each other.

Plate V, Fig. 4, shows a photomicrograph of one of the exterior bundles. The wood is shown above, then comes the phloem, flanked below by the thickened parenchyma. On either side are the parenchyma cells characteristic of the major part of the flower stalk. The intercellular spaces are quite noticeable.

Cross sections of the stalk, which happen to be under or at the base of the leaf (Plate V, Fig. 3), show invariably a migration of bundles from the inner toward the outer row, and from the outer toward the leaf. This would seem to indicate that both rows of bundles consist of leaf traces, but for reasons which will be given later, it is certain that this is only directly true of the outer row, which may be considered, then, to be both cauline and leaf trace, whereas the inner row is cauline.

The epidermal cells of the flower stalk are somewhat irregularly thickened, and contain stomata. Strange to say, there are no stomata on either surface of the leaves, another indication of the greater depth of parasitism to which this particular member of the *Orobancheæ* has descended.

The *Orobancheæ* in general have more numerous stomata than most parasitic plants (Unger, Exantheme d. Pfl.), but *Conopholis* is not the only member in which they are curiously placed. *Lathræa Squamaria* has them on the pistil only (Krause), while in the closely allied species, *L. clandestina*, they are in normal numbers and on the leaves (Duchartre).

Immature Flowering Stalks.

Plate IV, Figs. 1, 2, 3 and 4, are photomicrographs of vertical sections through young buds of flowering shoots. It will be observed that in Figs. 1, 2 and 4 are plainly seen the outer and an inner row of fibro-vascular bundles already described in the adult shoot. These anastomose with each other and in no case "end blindly beneath the apex of the stem" as they are said to do in other genera of *Orobancheæ* (de Bary).

Figure 3 is taken from a section cut at such an angle that the anastomosis of the numerous bundles of both the inner and outer circle is demonstrated.

In Fig. 2 it will be seen that the outer circle consists of leaf-trace bundles, and also that the inner circle anastomoses with it at intervals below, as well as at the apex. This as

well as Fig. 4 showed by higher magnification the spiral tracheæ, which make up about half of the fibro-vascular bundles. The dark spots at the base of all these figures are the sclerenchyma masses, which just below these buds make up almost the entire mass of the tubercle.

Each cell of the parenchyma of the shoot, in addition to a well-defined nucleus and nucleolus, contains from one to seven clear spherical, highly refractive bodies, on which even hydrochloric acid made no visible impression. Nevertheless, a set of sections left over night in the acid had in the morning scarcely a granule left, while another set which remained in alcohol over night still retained them.

These bodies are most numerous in the apex of the stalk. Further down they have lost their spherical outline, look to be disintegrating and finally disappear. About the region where they begin to disappear the patches of sclerenchyma begin to appear.

The bundles are well differentiated almost to the apex. They are made up, in about equal halves, of xylem and phloem, the former consisting of spiral tracheæ and wood cells. In the adult phloem a few sieve tubes are found. The relatively large amount of phloem is interesting and characteristic of parasites in general. For obvious reasons such a plant does not need much wood, and the rather large amount in this case has some relation to the fairly abundant stomata, which are so often lacking in other plants of a similar habit.

Cross sections of a very young rhizome, just before it leaves the tubercle, seem to indicate that the outer row of bundles is first formed and that the inner circle is developed slightly later. Nevertheless, since the inner row represents the normal group of bundles, this is so contrary to what might be expected that my evidence seems to me scarcely to justify more than the suggestion that the order of development may be as indicated.

Chatin figures a third row of bundles—leaf-trace bundles

he calls them—in the angles of the rhizome and flower stalks, quite close to the epidermis. In many thousands of cross section of all ages and from all regions I have been unable to find anything of the kind. As I have already proved, the outer row of bundles is both trace and cauline, while the inner is exclusively cauline. Bundles of the inner group occasionally anastomose with those of the outer, however, and may in that way indirectly reach the leaves, although even this seems improbable.

Cross sections of the rhizome, made at its base, show a large number of bundles, rather irregularly arranged, it is true, but still plainly referable to two rings.

Chatin's statement that there are three concentric rings of bundles, together with the drawing of the same, can only be understood on the supposition that his material consisted of very young shoots, of which he made but a single section.

IX. Leaves.

The leaves of *C. americana* are numerous and imbricated. To their peculiar appearance, indeed, is due the generic name, *Conopholis*, *i. e.*, cone-scale.

As has been already stated, they are yellowish-brown in color, at first inclined to be fleshy, but afterward membranous in texture.

The epidermis consists of thick walled cells, and is much better developed on the under than on the upper surface. Plate VI, Fig. 6, shows the bead-like thickening of the walls in the under epidermis. To this, perhaps, as Chatin suggests, is due the absence of stomata on the leaf, and their presence in the thinner-walled epidermis of the flower stalk.

The walls of the parenchyma tissue immediately within the lower epidermis are much thicker than those of the same cells under the upper epidermis. There is no indication of palisade cells.

The mesophyll resembles greatly, both in the shape and

size of its cells and of the intercellular spaces, the parenchyma of the leaf stalk. In some of the cells are leucoplasts, but they are erratically distributed and not numerous. The clear refractive bodies, probably a glucoside, mentioned as existing in the cells of the young flowering shoots, but absent from the adult stalk, are here very abundant.

The bundles are collateral, as in the flowering shoot, lie parallel to each other, and vary in number from seven to eleven. Usually three of them are larger than the others.

X. Flowers.

The description of the flower has been already given, and allusion made to a rudimentary ovarian gland seen in a cross section of a young flower bud. This ovarian gland is particularly interesting in view of the fact that a well developed one is found in the adult flowers of *Phelipæa*, which in this and many other respects, already noted, closely correspond with those of *Conopholis.*

The fruit of *C. americana* is a two-valved, single-celled capsule. On the middle of each valve are developed two parietal placentæ bearing numerous seeds of fair size.

The seeds have well-developed endosperm, with small undifferentiated embryos.

A detailed study of the floral structure and of the embryology will be given in a later paper.

The following is a brief summary of results:

1. *Conopholis* is parasitic on the oak, and may form a fringe of growth round the trunk, at a distance of ten or more feet.

2. It is perennial to the extent of at least eight to ten years.

3. It first affects young roots, and usually starves the portion beyond the point of infection.

4. The union between parasite and host is an extremely intimate one, the parasite being practically developed endogenously within its host, which rises up and encloses it after its

germination. The resemblance in this respect is not to members of the *Orobancheæ*, but exactly to the *Balanophoreæ* and *Rafflesiaceæ*.

5. The irritant action of the parasite causes swelling up of the host root, and enormous multiplication of its sclerenchyma patches.

6. Each parasitic "tubercle" consists of a bark, sclerenchyma masses and possibly some cellular tissue belonging to the host, and of cellular tissue and bundle issue, chiefly developed in the flower stalks of the parasite.

7. The flowering shoots show two concentric rows of bundles.

8. The phloem masses of the bundles face each other.

9. Stomata are present over the flowering shoots, but absent from the leaves.

10. The leaves are brownish-leathery when mature, and are devoid of palisade tissue.

11. In cells of the leaves and young flowering shoots are numerous clear refractive bodies which may be of a glucoside character.

12. The flowers show a small ovarian nectar gland.

EXPLANATION OF PLATES I–VI.

Plate I. Three growths of *Conopholis*, on oak root, one-half natural size.

Plate II. Longitudinal section of *Conopholis* and oak root.

Plate III. Longitudinal section of *Conopholis* and oak root, opposite half to that figured in Plate II.

Plate IV, Figs. 1–4. Longitudinal sections of young flower shoots on oak tissue.

Plate V, Figs. 1 and 3. Transverse section of flower shoot of *Conopholis*, Fig. 1 $\times$ 30°, Fig. 3 $\times$ 50°. Fig. 2. Portion of stem showing double circle of vascular bundles, $\times$ 75°. Fig. 4. Single bundle, $\times$ 350°. Fig. 5. Longitudinal section of flower bud from young plant of *Conopholis*.

Plate VI, Figs. 1–4. Young plants of *Conopholis* attached to oak roots, natural size. Fig. 5. Patch of sclerenchyma cells from parasitic swelling. Fig. 6. Cells from epidermis of leaf of *Conopholis*.

Recent Observations on Amphicarpæa Monoica.

By Adeline Frances Schively, Ph. D.

Honorary Fellow in Botany.

THE results of certain experiments had not been determined, when my paper published in the last number of the "Botanical Contributions of the University of Pennsylvania" went to press. In order that the observations now to be discussed may be clearly presented, certain allusions to statements in the paper mentioned above will be found necessary.

A. monoica bears above ground, during August, racemes of purple flowers, whose productiveness is quite variable; but in most seasons a fair number of legumes may be gathered. These legumes are lanceolate or falcate in shape, and contain rarely two, usually three, seeds, which when ripe are grayish-green, flecked with purple. When immature, the legumes are green; later they become brown, and dehisce in the usual manner. The dorsal and ventral sutures are quite prominent, and are markedly hairy. The walls of the legume are not in close contact with the seeds; upon the outer surface of the walls a few scattered hairs occur.

In September, aerial greenish cleistogamic flowers appear, and by October have produced legumes differing in shape from those already described; the number of seeds varies from one to three; but the color of the seeds and the general features of the legume are similar to those resulting from purple flowers.

During the entire season, subterranean flowers are constantly developing. The legumes here produced are pyriform, and typically contain but one seed, which occupies the entire space. When immature, the legume walls are white,

Wilson on Conopholis.

WILSON ON CONOPHOLIS.

WILSON ON CONOPHOLIS.

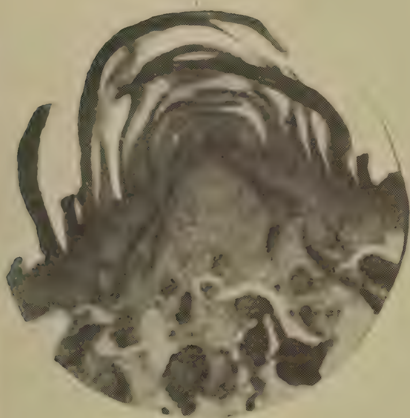

FIG. 1.

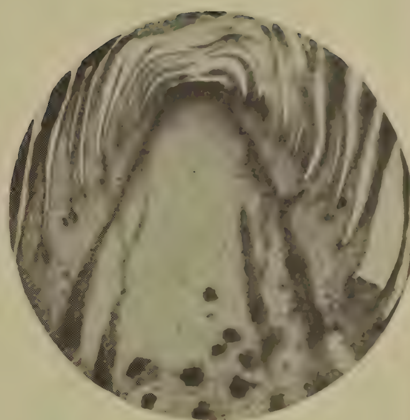

FIG. 2.

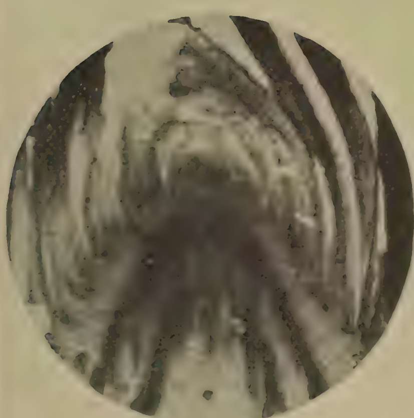

FIG. 3.

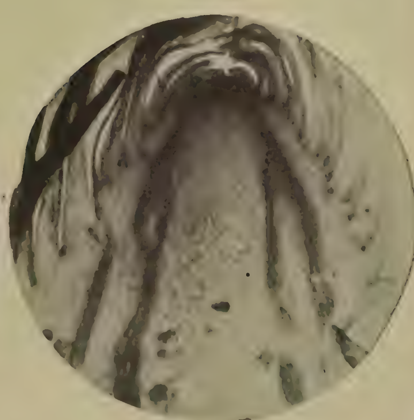

FIG. 4.

WILSON ON CONOPHOLIS.

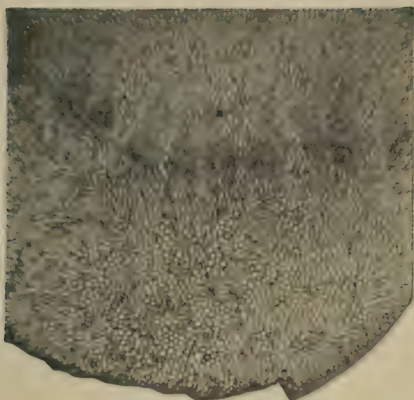

FIG. 1

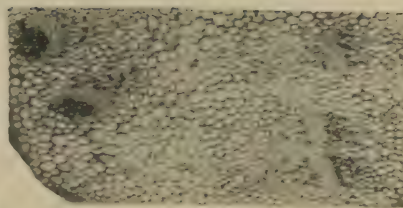

FIG. 2

FIG. 3.

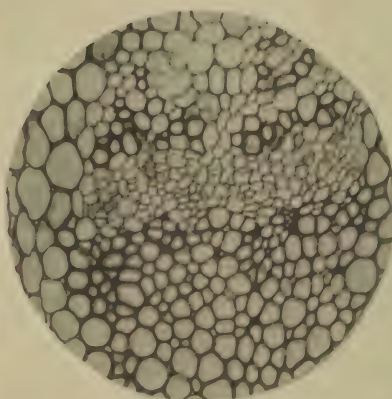

FIG. 4

FIG. 5

WILSON ON CONOPHOLIS.

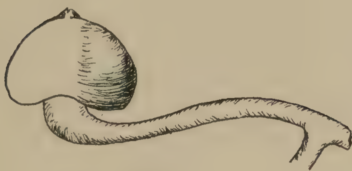

FIG. 1.

FIG. 2.

FIG. 3.

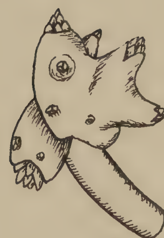

FIG. 4.

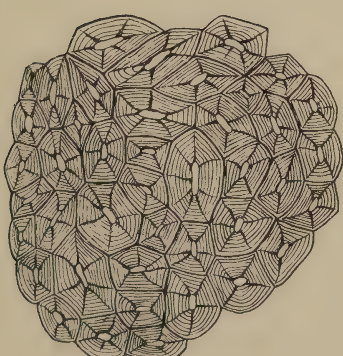

FIG. 5.

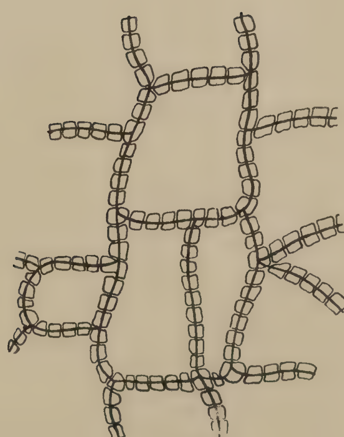

FIG. 6.

WILSON ON CONOPHOLIS.

DUE DATE	DATE RETURNED